Popular Scientific Summary

How Does Cook Stove Emissions Affect the Ice Formation in Clouds?

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Ice crystals in clouds trigger precipitation and affect how the clouds reflect sunlight. When there are more so-called ice nuclei present in the atmosphere, ice formation in clouds can increase. The ability of emission particles from biomass combustion to act as an ice nuclei has been studied in a research project at Umeå University. The results from these experiments indicate that biomass combustion particles might increase the atmospheric ice formation in regions where they are frequently abundant despite their low ice nucleating ability.

The formation of ice in the atmosphere strongly affects the properties of clouds and their impact on climate. Ice particles in clouds initiate precipitation formation, affects the hydrological cycle and reflect sunlight back into space more effectively than liquid water droplets. Therefore, ice formation is important to understand but up to this day it is not fully understood or explained by theory and experiments.

The troposphere extends from the Earths surface up to 10-15km above sea level. Clouds can form in the troposphere and they consist of either water droplets, ice crystals or both, depending on the temperature and relative humidity. For temperatures between 0 and -37 °C clouds consist of either supercooled water droplets and/or ice crystals and at colder temperatures, they consist of ice. A water droplet will not freeze to an ice crystal if the temperature is warmer than -37 °C and the explanation for this is that the freezing process involves overcoming an energy threshold which cannot happen unless it is really cold. Although, there are special particles called ice nuclei that can make ice form on their surface for temperatures warmer than -37 °C. Some examples of ice nuclei are dust particles, some types of bacteria and emission particles from combustion processes whose ability to trigger ice formation is tested in this project. Some ice nuclei are very efficient at forming ice, such as bio-particles and mineral dusts, whereas others are not as efficient. Efficient implies for example that the ice nuclei can trigger ice formation at relatively warm temperatures and low relative humidity.

In a laboratory at Umeå University, experiments that mimicked how ice is in the atmosphere were performed. More specifically, the ice formation potential of biomass combustion particles was studied. The biomass emissions were generated from combustion of biomass fuels in a variety of cook stoves relevant for Sub-Saharan East Africa since domestic cooking and heating is a large source of combustion emissions. The measurements indicated that biomass combustion particles, such as soot, are not so efficient at triggering ice formation but since combustion particles are very abundant in the atmosphere in comparison other more efficient ice nuclei, they may still have a great impact on ice formation in clouds on regional and global scales. Fig.1 depicts possible atmospheric implications when potential ice nuclei are emitted from a cook stove. For freezing catalysed by ice nuclei, other ice forming mechanisms than the one depicted in this figure (where the ice nuclei is immersed in a cloud droplet) exist. Soot particles are assumed to be responsible for the observed ice formation in Umeå but its potential to act as ice nuclei is controversial and proven to be highly variable. To investigate the role of soot in the atmospheric ice formation process is therefore encouraged as well as further research on ice in clouds due to its large impact on climate and clouds.

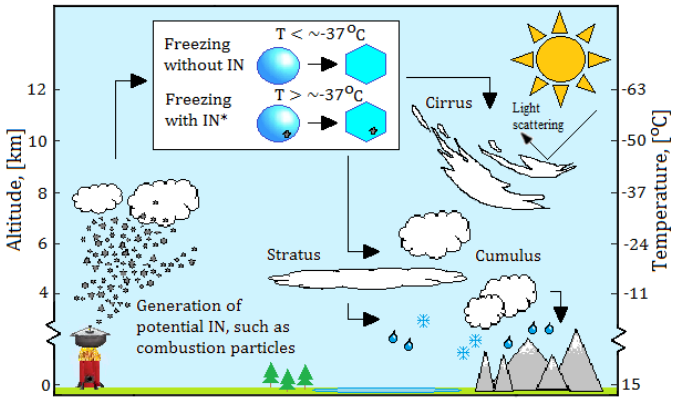

Figure 1. Potential ice nuclei (IN) can be emitted from biomass combustion in a cook stove. The particles are transported up in the troposphere and freezing with or without ice nuclei can occur depending on the atmospheric conditions. Different types of clouds can then form, such as high cirrus clouds consisting of ice or mid/low level clouds (stratus/cumulus) consisting of both water droplets and ice. Ice crystals in clouds can initiate precipitation which transports water back to the Earths surface as well as affecting how clouds reflect sunlight.